SnowEx: a NASA airborne campaign

leading to a snow satellite mission

SnowEx update: February 2, 2017

SnowEx Team/contributors to this report: Edward Kim, Charles Gatebe, Jerry Newlin, Kelly Elder, Ludovic Brucker, Chris Hiemstra, HP Marshall, Stephen Rorke, Eugenia De Marco, Tom Painter, Delwyn Moller, Amanda Leon, Rani Gran, Julie Malingonski

Sponsored by NASA Headquarters/Terrestrial Hydrology Program Manager: Jared Entin

Agenda Outline

- Welcome – E. Kim/C. Gatebe
- Winter Ground Logistics Updates – K. Elder/L. Brucker/C. Hiemstra/HP Marshall
- Aircraft Logistics Updates:
  - NRL P-3 (AESMIR, CAR, IR Sensors, SnowSAR) – **S. Rorke/E. Marco**
  - King Air/ASO (Lidar & Spectrometer) – **T. Painter**
  - G-3/UAVSAR & GLISTIN-A – **D. Moller/Y. Lou**
- Data Management Updates - Amanda Leon
- SnowEx Weather Products/Plans – NWS/J. Malingowski
- Public Outreach – R. Gran
- Schedule & General Logistics Updates – J. Newlin/M. Thomas
- Updates from NASA HQ – J. Entin
- Q&A

WINTER GROUND LOGISTICS UPDATES

K.Elder/L. Brucker/C.Hiemstra/HP Marshall

Ground Team

SnowEx Ground Generic Schedule

Actual schedules will vary on daily basis based on constraints that arise from:
1) Safety and health issues
2) Weather
3) Science needs and accomplishments
ranked by priority – safety will always be deciding factor in all operations and decisions

SUNDAY
Transportation day
Field workers on site will check out and leave Grand Mesa
Incoming field workers will arrive and check in
Schedules will depend on safety, weather, and arranged transportation
1745 Vans leave Grand Mesa Lodge (GML) for Mesa Lakes Lodge (MLL)
1800-1900 Dinner at MML
1900 Evening orientation – ATTENDANCE MANDATORY
Welcome and introductions – Elder
NASA overview – Kim
Ground overview – Elder
Safety and logistics overview – Newlin

MONDAY
Training day – ATTENDANCE MANDATORY
See training day schedule/details

Questions→ kelly4snowex@gmail.com

Ground Team

SnowEx Ground Generic Schedule

TUESDAY – SATURDAY
Field measurement days

0530 – Airborne telecon
0600 – Science, Airborne, and Safety Team leaders telecon
includes Grand Mesa (GM) and Senator Beck Basin (SBB) team leads
0600: Vans leave GML for MLL
0630-0715: Breakfast at MLL
0715-0745: Daily safety meeting, weather update, daily team assignments
– ATTENDANCE MANDATORY
0745-0800: Equipment issue to field team leaders
0800: Vans to GML
0830: Field crews leave for destinations – begin field measurements
1200-1230: Field crew lunch, system-wide check in with assigned contacts
Status, location, plans
1230-1600: Continue field measurements
1600-1700: Leave field locations for lodges
1745: Vans leave GML for MLL
1800: Data delivered by field team leaders to data team,
equipment turned in to quartermaster
1800-1900: Dinner at MLL
1900-2000: Daily debriefing – ATTENDANCE MANDATORY
safety update
weather update
airborne update
lessons learned
data issues discussion
tomorrow's plan
2000: Vans leave for GML
2015-2100: Science, Airborne and Safety Team lead meeting/telecon at MLL
includes GM and SBB team leads

Questions→ kelly4snowex@gmail.com

Ground Team

SnowEx Ground Generic Schedule

Topics we need to cover

SUNDAY (after dinner)

Introductions – all
Objectives of program and campaign (Ed)
Overview of field areas (Chris H, Ludo, HP)
Daily schedule (Kelly)
Weekly schedule\ Mandatory attendance functions (Kelly)
Optional attendance functions (Kelly)

MONDAY (all day)

Emergency response plan (Mark Thomas)
Safety plan (Mark Thomas)
JHAs (Kelly)
Daily tailgate safety meetings (Kelly)
Communications
- Radio (Joe Oblais from USFS will give radio training at 0900)
- Sat Phones (Omaya Odiaga)
- In Reach (Omaya Odiaga)
- Cell Phones
- Landlines
- Relevant numbers and emails

Maps (Chris H)
Check-in, Check-out – when, where, to whom (Mark Thomas)
Buddy system (Kelly)
Field group dynamics – moving as a unit, no solo travel, etc. (Kelly)
Snowmobiles – operation, safety, maintenance (Mike at GML)
Snow Pits (LSOS – outside at MLL) (indoor part in MML) (Gang of 4)
Depth Transects (LSOS – outside at MLL) (indoor part in MML) Gang of 4)
Personal equipment (Kelly)
Snowshoes, skis (Kelly)
Meals, Housing , Parking, Snow removal, Equipment issue and return; equipment care (Tim Niemeyer)
Data delivery (NSIDC person); Anti-harassment (Kelly); Booze/drugs (Hunter S. Thompson)
Medical situations

AIRCRAFT LOGISTICS UPDATES

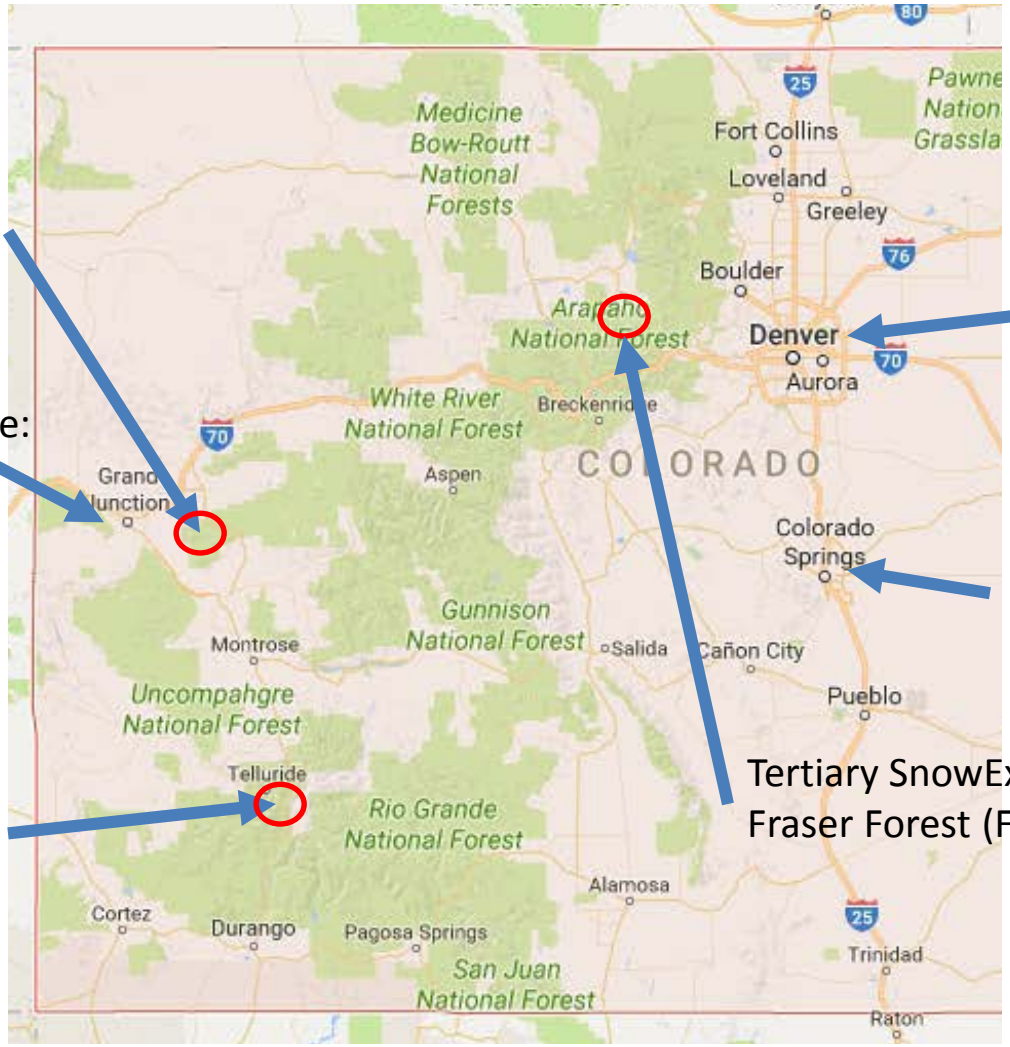
ConOps Detail 2
Map of SnowEx Target Locations and Aircraft Bases

Primary SnowEx site:
Grand Mesa (GM)

King Air & Twin Otter base:
Grand Junction (KGJT)

Secondary SnowEx site:
Senator Beck Basin (SB)

AFRC G-III base:
AFRC (KPMD)



JSC G-III bases:
Centennial (KAPA)
& AFRC (KPMD)

P-3 base:
Peterson AFB
(KCOS)

Tertiary SnowEx site:
Fraser Forest (FF)

ConOps detail 3 – deconflicting all aircra

Safety considerations (discussed & agreed at 11/3/16 all-pilots telecon; blue mods TBC by future telecon)

- Common radio frequency (to be selected)
- Target boxes defined for GM & SB sites; sensors will image these boxes
- Larger "exclusion box" defined for GM & SB sites (allows for turns)
- Each aircraft to make radio calls before entering and after leaving exclusion box, and report altitude
- Only one aircraft in an exclusion box at a time *at a given altitude*
- AGL altitudes to be defined relative to a single reference location within boxes (since terrain height varies within target boxes)
- Minimum vertical separation 1000 ft
- G-IIIs may de-conflict in time rather than the above procedure
- **Actions of one aircraft or sensor can impact other aircraft/sensors & ground activities, so deviations from plans must be communicated to overall Airborne Lead who then informs Ground Lead; feedback goes in reverse direction**
- Any deviation or abort decisions, etc. to be made by on-board lead for each aircraft & filtered through overall Airborne Lead
- Certain communication/decision/abort scenarios to be ironed out in advance in case Airborne Lead is not reachable.

- Fraser site (FF) to be flown over during transit from Peterson to GM (P-3 only)

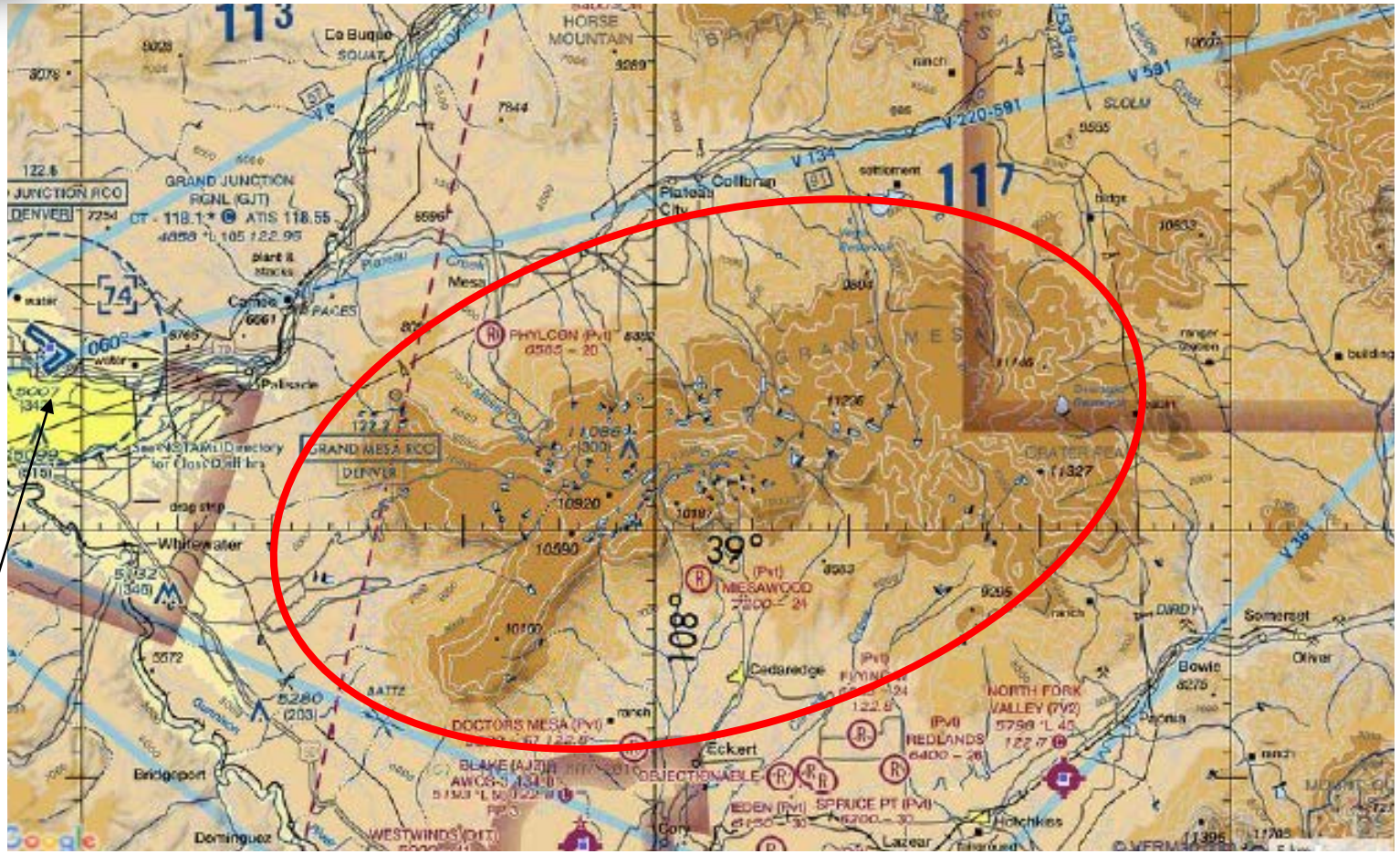
Grand Mesa Altitudes

Altitudes (in feet) over GM target

- Hours of available daylight are a constraint
- Altitudes optimized for SnowEx objectives
- P-3: (3 altitudes) 1000 AGL for AESMIR, match ASO altitude 3000 AGL for CAR, 6000* AGL for SnowSAR
- ASO: optimize for high shots/m2 in target box in single sortie, same altitude as fall 2016 flights
- G-III/UAVSAR: 41000 MSL
- G-III/GLISTIN-A: 41000 MSL
- WISM: 5000-7000 AGL*

- * to be adjusted after test flight

ConOps detail – Primary Site: Grand Mesa,



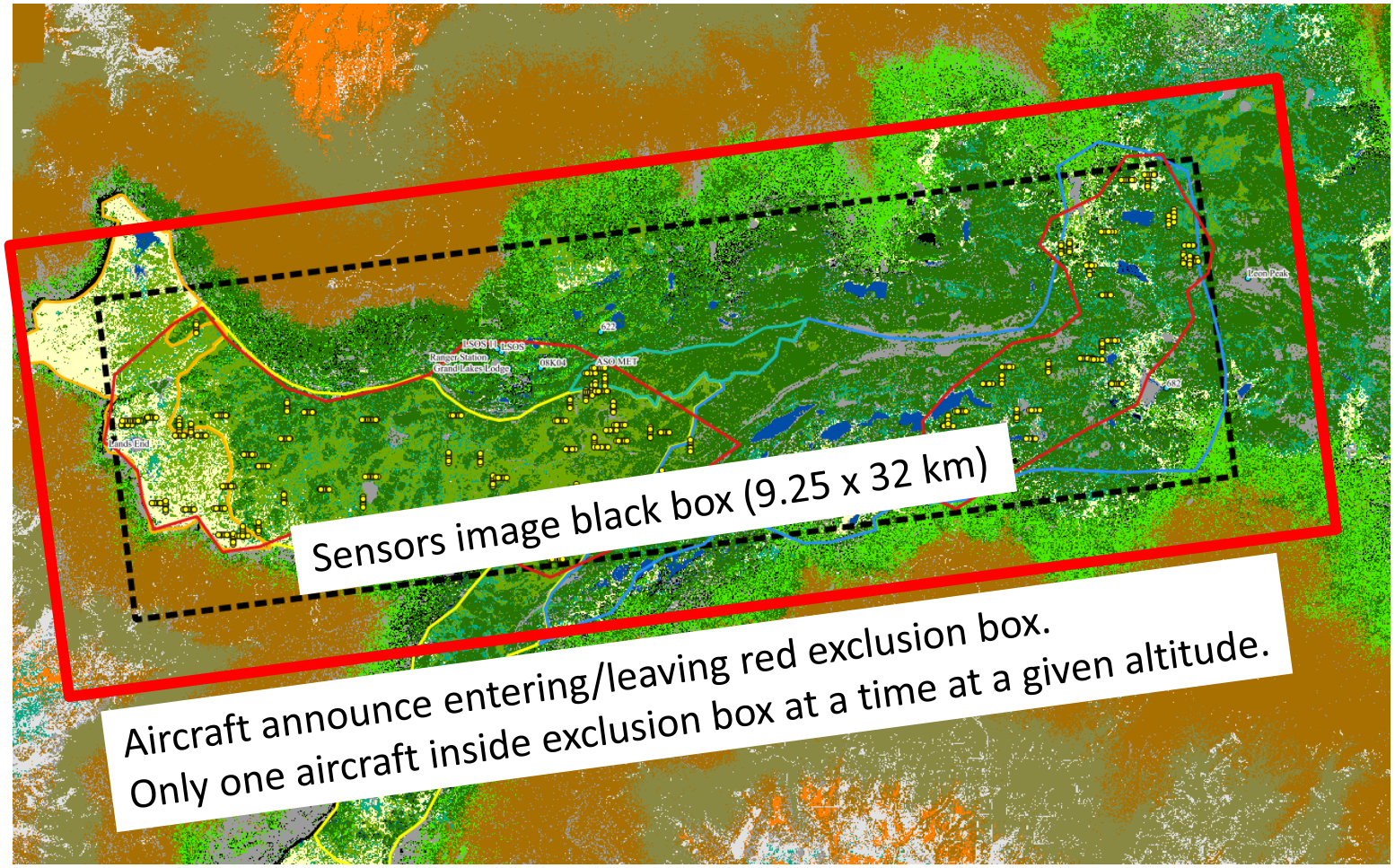
Grand Junction, CO

5 km

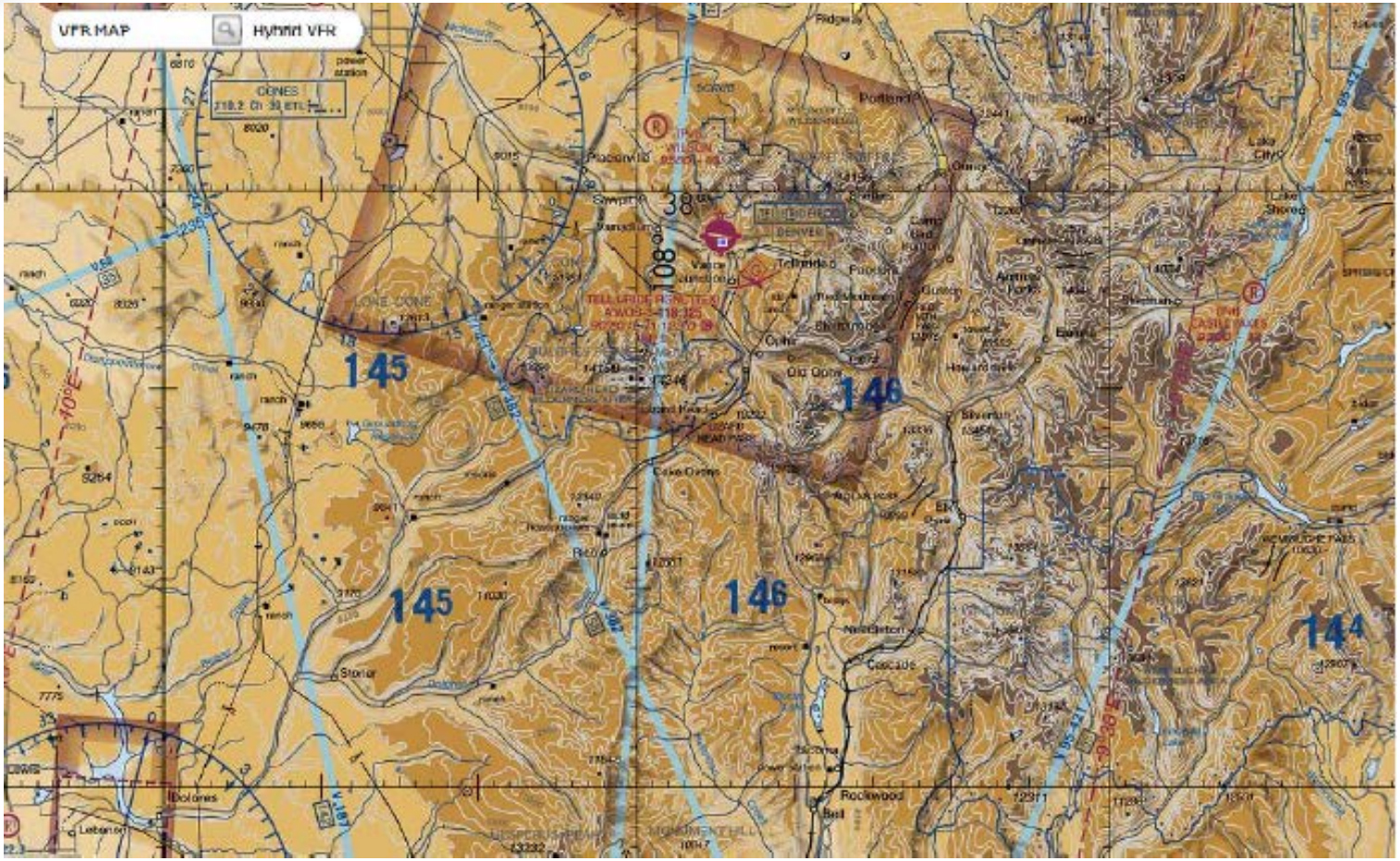
Elevation ~10000ft MSL, ~5000ft above surrounding area. Fairly flat on top.

ConOps detail – GM Primary Site

GM target box, exclusion box

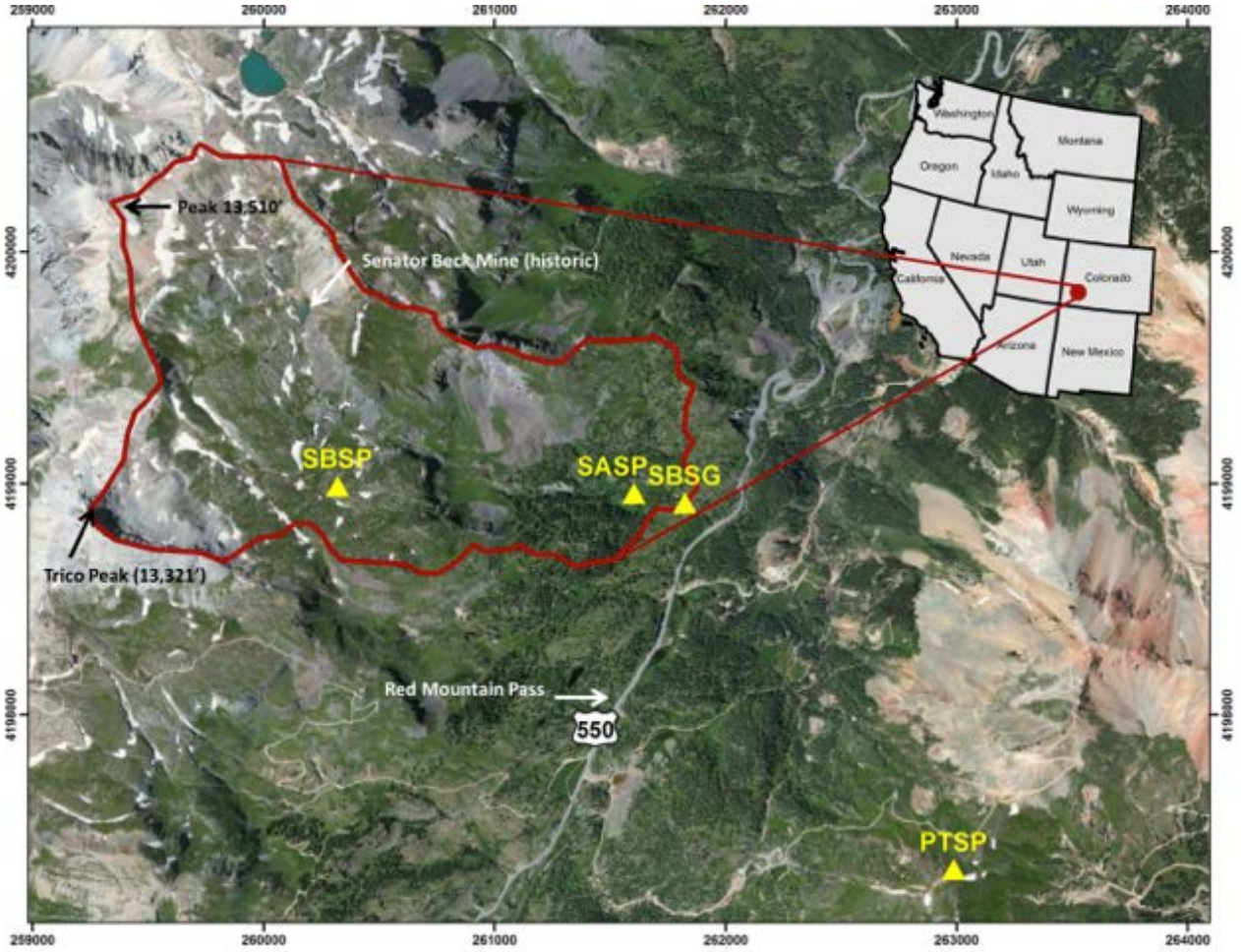


ConOps detail –
Secondary Site: Senator Beck Basin, CO



Elevation 10000 – 14000+ ft MSL. Mountainous terrain.

ConOps detail – Secondary Site: Senator Beck Basin, CO



Elevation 10000 – 14000+ ft MSL. Mountainous terrain.

Senator Beck Altitudes

Altitudes (in feet) over SB

- Hours of available daylight are a constraint
- Altitudes optimized for SnowEx objectives
- P-3: (1 altitude) ~~1000 AGL~~, ~6000* AGL (~17kft MSL) for SnowSAR, match ASO altitude (~17kft MSL) for CAR circles
- ASO: optimize for high shots/m2 in target box in single flight, same altitude as fall 2016 flights (~17kft MSL)
- G-III/UAVSAR: 41000 MSL
- G-III/GLISTIN-A: 41000 MSL
- WISM: n/a, not flying over SB

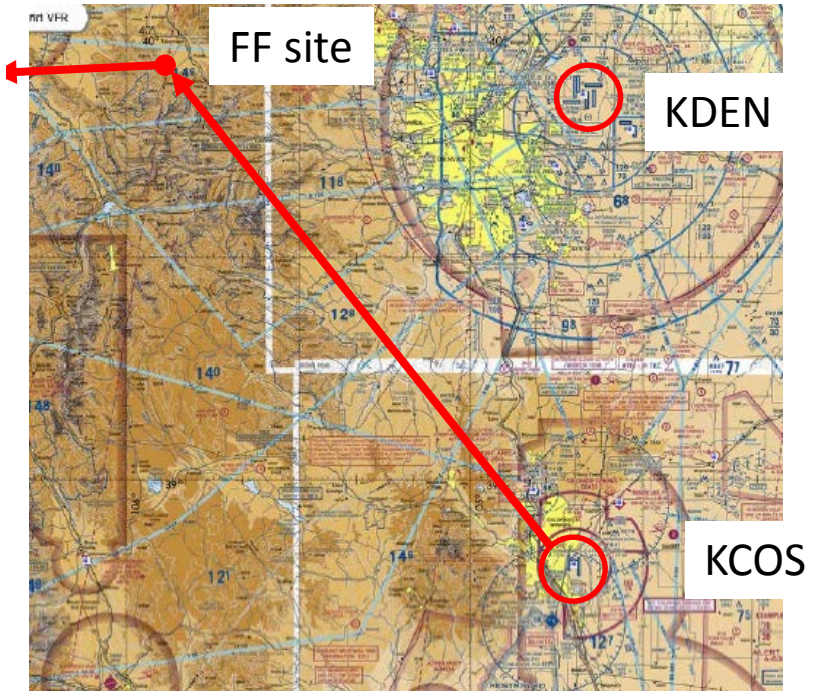
* to be adjusted after test flight

ConOps detail – Fraser Forest Tertiary S

Point site at Lat/Lon
39.9059, -105.8837

P-3 only will overfly
At ~6000ft AGL
during KCOS to GM leg

Observation will take
only seconds



P-3 Schedule

- Test Flights 1/26-1/31
- Planned transit to Peterson AFB in Colorado Springs is 2/1 with SnowEx Campaign beginning 2/6
- First official flight likely 2/7
- 5 or 6, 8 hour flights are planned over the SnowEx sites (Grand Mesa, Senator Beck) and these will be spread over the campaign period of performance depending on weather conditions
- Transit back to PAX will occur during the last week of February with a fly over Michigan for a separate, but related effort (See back up)

G-III Notional Schedule

(all dates subject to change)

JSC aircraft schedule

- 3Feb - KEFD-KPMD
- 4Feb - Cal & SacDelta - L-Band
- 6Feb - SNOWEX - L-Band
- 7Feb – swap pods
- 8Feb - SNOWEX - Ka-Band
- 9Feb – SNOWEX backup day
- 10Feb - KPMD-PHKO
- 11-16Feb - Volcano - Ka-Band
- 17Feb - PHKO-KAPA
- 18-24Feb - SNOWEX Ka-Band (3 sorties)
- 25Feb - KAPA-KEFD

AFRC aircraft schedule

- All flights KPMD-KPMD
- 18Feb – upload L-band @KPMD
- 20-25Feb - SNOWEX - L-Band (2 sorties)
- 2Mar- SacDelta - L-Band
- 3Mar– SNOWEX - L-Band

Basic daily schedule 1/2
(all times are Mountain time zone)

- The daily schedule for airborne ops is

- 1700-1745 window for weather briefing by NWS (avoid 1600-1700 shift change)
- 1700-1800 Fly/no-fly decision for next day (decision may be earlier if weather makes it obvious)
- 1800-1900 dinner hour for ground team at GM
- 1900-2000 daily de-brief by ground team at GM, show airborne quick looks if available
- 2015-2100 daily evening telecon w/all aircraft, ground truth, wx, etc.

- 0515-0530 Early morning final wx check & go/no-go (if “no fly” decided the previous day, this morning gate will NOT convert that decision to “fly”, only the other way around); note avoid NWS shift change at 0600
- 0600 – Science, Airborne, and Safety Team leaders telecon

- IF “NO-FLY”, aircraft will stand down (ground truth goes regardless)

Basic daily schedule 2/2
(all times are Mountain time zone)

- IF “FLY” (note morning obs over targets are favored vs. afternoon to avoid possible wet snow)

- **0800 P-3**: takesoff from KCOS (Peterson), fly over Fraser on the way to GM, execute GM flight lines, transit to SB, execute SB flight lines, return to KCOS. Flight duration 8 hrs max.
- **King Air**: take off from KGJT, exact time cloud dependent, (choice of flying GM or SB first must be coordinated with P-3 & WISM), return to KGJT. Flight duration ~5 hrs max. 2nd flight may be needed same day to cover both target boxes.
- **G-IIIs**: take off from KAPA or KPMD, execute lines at GM & SB, return back to base. Flight duration ~3 hrs if from KAPA, ~5hrs if from KPMD. Only dates when both G-IIIs fly are Feb 20-24 when UAVSAR at KAPA and GLISTIN-A at KPMD. On single G-III days, take off at 0800MT. On dual G-III days, if flights are de-conflicted in time, prefer UAVSAR flight first to avoid any wet snow conditions. UAVSAR take off time 0800 MT from KAPA. GLISTIN-A enters observing area 1 hour after 1st G-III has exited observing area (~1200MT), so take-off from KPMD ~1000MT/0900PT.
- **Twin Otter**: take off from KGJT, fly own flight lines over GM, return to KGJT. Must coordinate w/P-3 and King Air. Exact times flexible because transit time to GM is short, but mornings are preferred to avoid any wet snow conditions.
- **Post flight**: Data backup, quick look generation.
- REPEAT daily

NRL P-3

Integration completed: 2/1

Aircraft testing: 2/2

Science test flights: 2/3 – 2/4

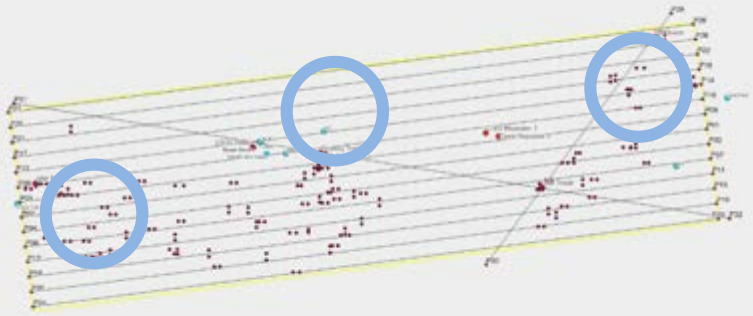
Transit to Colorado: 2/6

First science flight: 2/7

ASO King Air Status

ConOps detail – GM flight lines

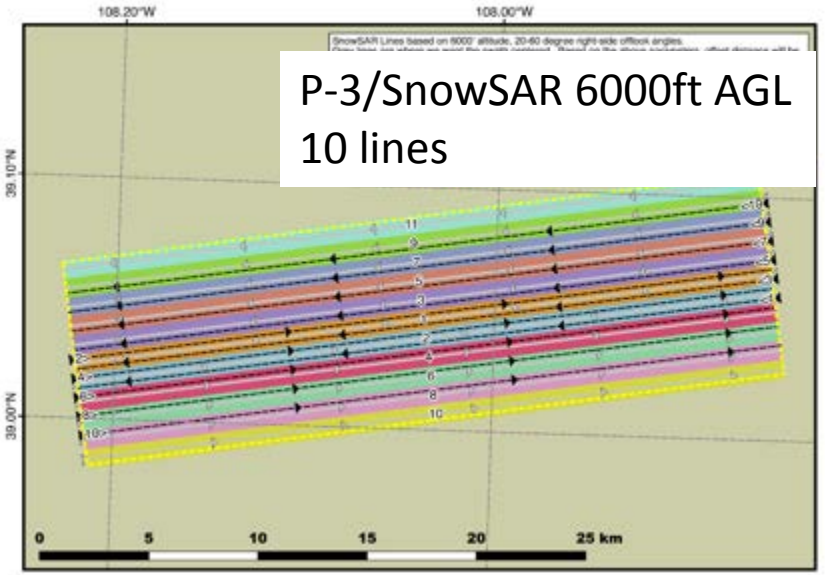
P-3/AESMIR 1000ft AGL (12 lines)



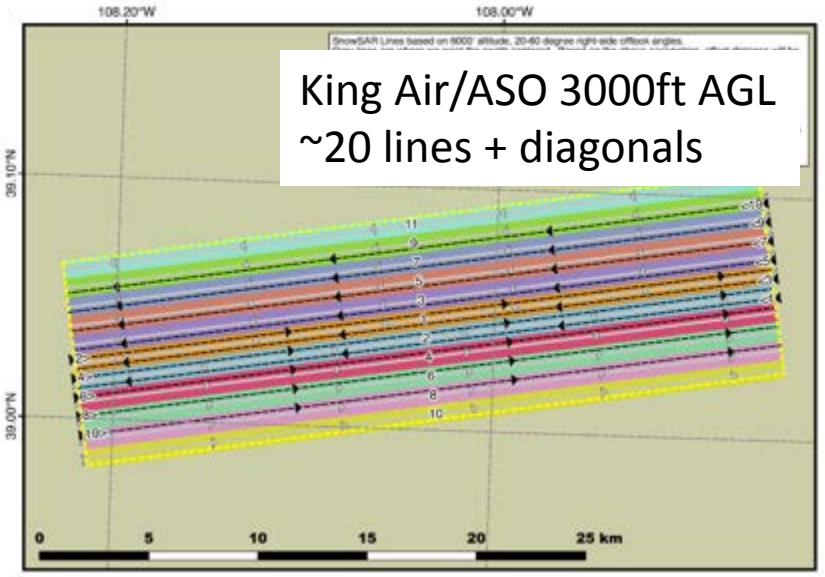
P-3/CAR 3000ft AGL (3 circles)

For CAR sensor, P-3 will perform circles of 3-4 minutes duration over ~3 points in the target box, at same altitude as the ASO flight lines (but not at same time!).

P-3/Thermal IR suite & video camera will not have its own dedicated altitude but will record continuously during whole flight.

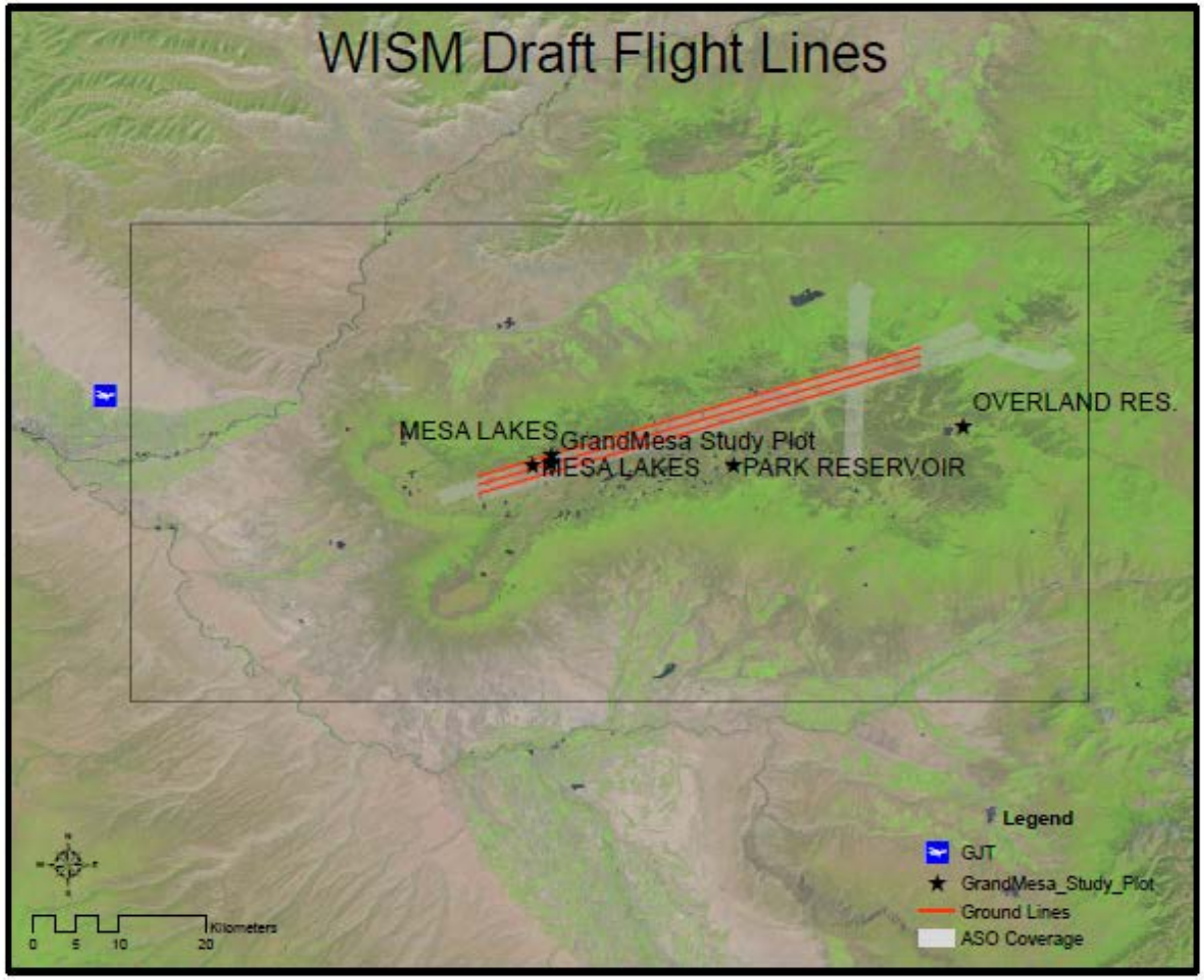


P-3/SnowSAR 6000ft AGL
10 lines



King Air/ASO 3000ft AGL
~20 lines + diagonals

WISM Flight Lines (GM site only)



- All flights out of KGJT
- Flight altitudes 2500-4000 or 5000 - 7000 ft AGL
- Will coordinate with SnowEx planes.
- ~10 flight hours available from 31 January to 10 February 2017.
- 3-4 engineering flights over GJT airport 31 Jan – 4 Feb, 2017
- 2 Science Flight over Grand Mesa 5 Feb – 10 Feb, 2017; 3 hrs duration each.

Figure 1: Map of study area showing flight lines (red), ground stations (stars) and GJT airport.

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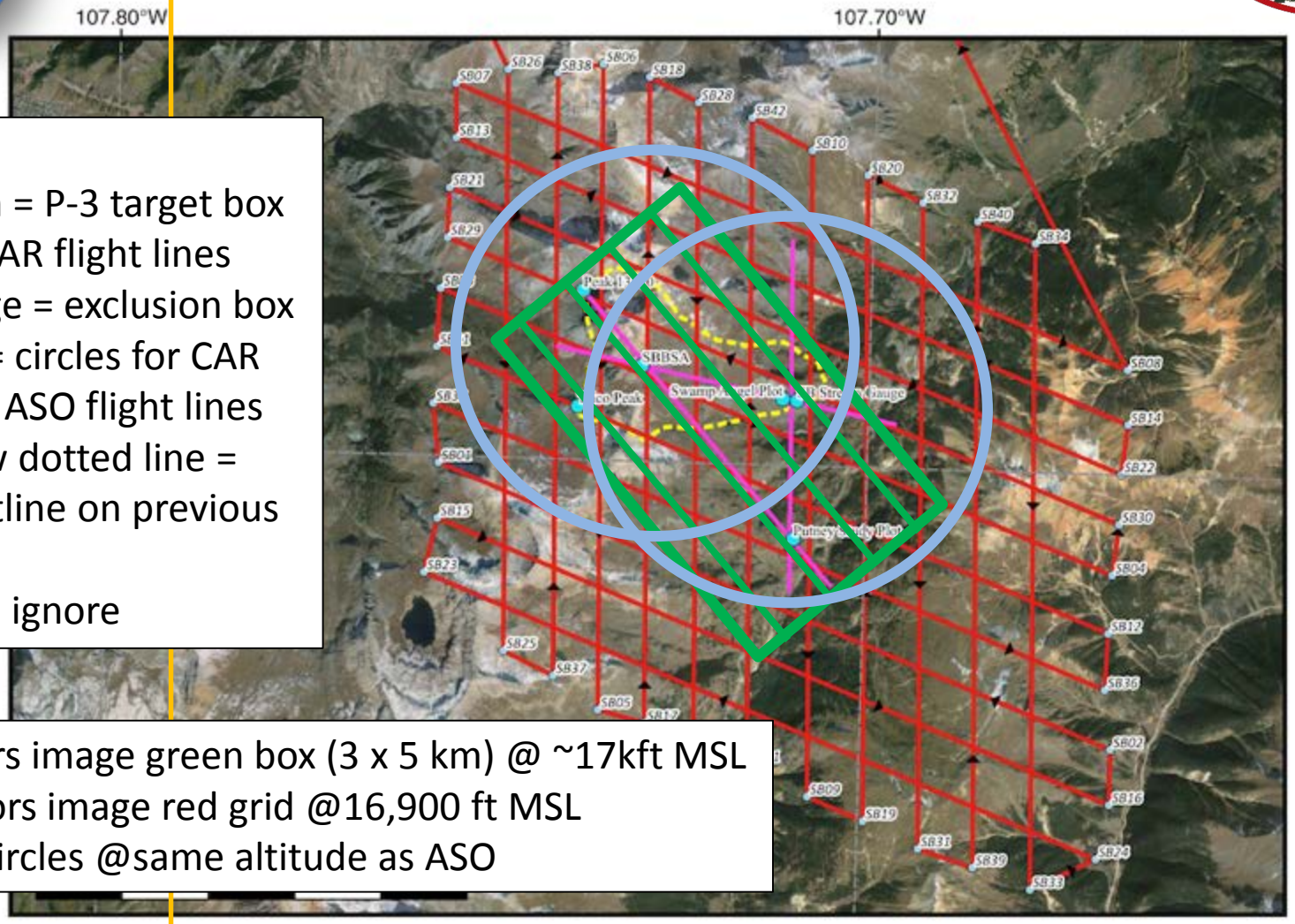
ConOps detail – SB Flight Lines & Boxe



LEGEND:

- Green = P-3 target box & SnowSAR flight lines
- Orange = exclusion box
- Blue = circles for CAR
- Red = ASO flight lines
- Yellow dotted line = basin outline on previous slide
- Pink = ignore

P-3 sensors image green box (3 x 5 km) @ ~17kft MSL
ASO sensors image red grid @16,900 ft MSL
Blue P-3 circles @same altitude as ASO

Aircraft announce entering/leaving orange exclusion box.
Only one aircraft inside exclusion box at a time at a given altitude.

UAVSAR & GLISTIN-A Flight Lines

Same as
Fall 2016 SnowEx
GLISTIN-A
flight lines

Lines @ 41kft MSL

JSC G-III bases:
Centennial (KAPA)
& AFRC (KPMD)

AFRC G-III base:
AFRC (KPMD)

DATA MANAGEMENT UPDATES

Amanda Leon

Shadowing at Grand Mesa

- Shadow instrument collection teams
  - Gain insight into collection methods and end of data processing
  - Initiate data discussions with instrument POCs

- Email sent to instrument POCs to request assistance in arranging shadowing

GBRS Instrument POCs

Instrument	Name
GPS antenna on weather stations	Eric Small
Microwave radiometers	Alexandre Langlois
Microwave radiometers	Roger DeRoo
Pluvio	Ana Barros
Parsivel disdrometer	Matt Wingo
PIP	Larry Bliven
Radar	HP Marshall*
Scatterometer	Richard Kelly
Spectroradiometer	Karl Rittger*
Sun photometer	Jason Kraft
Time-lapse camera	Mark Raleigh*
Tree accelerometers	Mark Raleigh
TLS	Jeff Deems*

* Represents multiple instruments

Field Instrument POCs

Instrument/Collection Type	Name
Snow Pit	Kelly Elder*
Snow Depth Transects	Kelly Elder*
SMP	Chris Derksen*
SSA	Nick Rutter*
Magnaprobe	Chris Hiemstra*

* Represents multiple instruments/measurements

WEATHER PRODUCTS/PLANS

NWS/J. Malingowski

Decision Support Briefing for SnowEx (NASA)

Overview

High pressure will break down late this week and begin a more active weather period for western Colorado. Light snow is expected to occur overnight Friday into Saturday morning on the Grand Mesa with about 2 to 4 inches possible.

National Weather Service Forecast for 10 Miles NNW Cedaredge CO (Grand Mesa at Mesa/Delta Co Line)

For the latest forecast, go to http://forecast.weather.gov/MapClick.php?lat=39.027&lon=-108.02

This Afternoon: Mostly sunny, with a high near 36. South southwest wind around 10 mph.
Tonight: Partly cloudy, with a low around 20. South wind around 10 mph.
Thursday: Partly sunny, with a high near 33. Southwest wind 5 to 10 mph.
Thursday Night: Mostly cloudy, with a low around 21. Southwest wind 5 to 10 mph.
Friday: Partly sunny, with a high near 34. South wind 5 to 10 mph.
Friday Night: A 50 percent chance of snow, mainly after 11pm. Mostly cloudy, with a low around 22.
Saturday: A 40 percent chance of snow. Mostly cloudy, with a high near 31.
Saturday Night: Mostly cloudy, with a low around 20.
Sunday: Mostly sunny, with a high near 31.
Sunday Night: Mostly cloudy, with a low around 20.
Monday: Snow likely. Mostly cloudy, with a high near 30.
Monday Night: Snow likely. Mostly cloudy, with a low around 18.
Tuesday: Snow. Mostly cloudy, with a high near 26.

National Weather Service Forecast for 7 Miles ENE Ophir CO (Senator Beck)

For the latest forecast, go to http://forecast.weather.gov/MapClick.php?lat=37.905&lon=-107.72

This Afternoon: Mostly sunny, with a high near 32. Breezy, with a west southwest wind around 20 mph.
Tonight: Partly cloudy, with a low around 16. Breezy, with a southwest wind 15 to 20 mph.

Aviation Forecast for Grand Junction Regional Airport

```
KGJT 011736
TAFGJT
TAF
KGJT 011736Z 0118/0218 20003KT P6SM BKN200
     FM012000 31005KT P6SM SCT110 BKN200
     FM020200 06004KT P6SM SCT110 SCT200
     FM021200 12005KT P6SM OVC200=
```

Aviation Forecast for Colorado Springs Airport

```
KCOS 011720Z 0118/0218 16008KT P6SM SCT150
     FM020300 12010KT P6SM FEW010 BKN020
     FM020700 10007KT 4SM BR OVC007
     FM020900 12007KT 1SM -FZDZ BR OVC003=
```

Aviation Forecast for Centennial Airport

```
KAPA 012043Z 0121/0218 35010KT P6SM BKN012 BKN080
     FM012200 02008KT P6SM SCT015 BKN080
     FM020000 06008KT P6SM SCT008 BKN020 BKN050
     FM020200 08010KT P6SM BKN010 BKN020 OVC040
     FM020300 06007KT 2SM BR SCT004 OVC008
      TEMPO 0203/0207 1/2SM -FZDZ FZFG OVC004
     FM020700 09008KT 1/2SM -FZDZ FZFG OVC004
     FM021000 14007KT 3SM BR BKN006 OVC012=
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Non-Technical Discussion

Grand Mesa forecast cloud levels:
Thursday: 10000ft AGL in early morning lowering to 6000 ft AGL by 6am MST...then lowering to 3000 ft AGL by 6pm MST.

Senator Beck forecast cloud levels:
Thursday: Low scattered cloud deck between 2000 ft AGL and 7000 AGL at 6am. Low cloud deck breaking out around 1100 MST. 8000 ft broken cloud deck developing around 8000 ft AGL.

Current PIREPs: https://www.aviationweather.gov/airep/plot?type=turb&region=SW

Current SITREPs: https://www.aviationweather.gov/sigmet

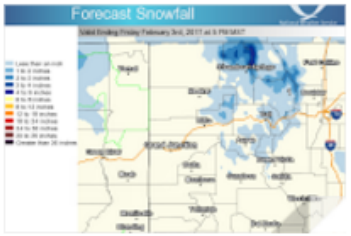
Current radar: http://radar.weather.gov/radar.php?rid=GJX&product=NCR&overlay=11101111&loop=yes

Current satellite: http://www.weather.gov/satellite?image=ir#ir

For Further Information

- Contact National Weather Service operations 24 hours a day at 970-256-9463 (unlisted)
- For specific support of emergency response incidents, request a spot forecast by contacting the NWS forecast office by phone or online.
- Online spot forecast request available at: http://www.weather.gov/spot/monitor/?lat=39.0293452169889&lon=-109.20392753906285&z=7

Forecaster: Julie Malingowski



PUBLIC OUTREACH

Rani Gran

Snow Ex Communications

Snow EX Media Messages:

The goal of SnowEx is to test new techniques and technology for measuring snow water extent from above so that we can develop a satellite to measure snow water extent globally.

Changes in snow water content has consequences. SWE are of significant interest to communities across the globe, in particular as it relates to the availability of fresh water, natural hazards, winter-dependent industries, and ecosystem impacts.

The is not just a NASA campaign. Snow experts Universities, other U.S agencies, and scientists from Canada and Europe are participating.

Snow Ex Communications

Snow Ex Media Day

- Tentative Date: Tuesday Feb. 13. This could slide based on flight schedules. Ellen Gray and Joy NG from the office of communications will be there.
- Media Advisory will go out Jan. 17
- Participants: Ed Kim NASA Goddard, Frank McCormick, US Forest Service, Brian Domonkos, Natural Resources Conservation Service, Colo, Tom Painter JPL, LT. Denise Miller, NRL Pilot
- Facebook live 1:00 PM with Ed Kim, Frank McCormick and NRL pilot

SnowEx Communications

- NASA SnowEx overview feature will go out Feb 7, a day when flights start in Colorado.
- Snow Ex Technology feature will go out on media day, Feb 13
- Joy(Videographer) will fly on the first flight.
- We are in the process of enabling media to fly on the P-3. That would be 1 to 2 per flight. Numbers is dependent on seat availability. NRL PAO is working the waivers.
- We hope to get a freelance videographer to get video from the ground station in Grand Mesa, Colodo.
- Forest Service is taking the lead on working with media visits at the ground station.
- Social media products (Ellen and Joy)
  - Facebook live on the media day
  - 2 Snap chat stories
  - opportunities for scientists in the field to contribute

SCHEDULE AND GENERAL LOGISTICS

J. Newlin/M. Thomas


Q & A